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(54) METHOD FOR REALIZING FREQUENCY HOPPING AND A BASE STATION EQUIPMENT

VERFAHREN ZUR AUSFÜHRUNG EINES FREQUENZSPRUNGVERFAHRENS UND
BASISSTATIONANORDNUNG

PROCEDE DE MODULATION PAR SAUTS DE FREQUENCE ET EQUIPEMENT DE STATION DE
BASE

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WO-A-93/17507 **WO-A-93/20625**
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Description

[0001] The present invention relates to a method for implementing frequency hopping in a base station of a digital cellular radio system, in which base station a first signal modulated by base band data signal is transmitted on a certain carrier frequency, which signal is divided in the time domain into several time slots of which one time slot transmits the common control channel of the base station equipment and the other time slots information regarding different connections.

[0002] In cellular radio systems, the quality of a radio channel varies as a function of time and place. On many occasions a transmitting antenna and a receiving antenna are not within sight of each other due to obstacles formed by terrain or buildings in the line of sight, and thus the signal detected at the receiver is a sum of beams that have travelled different paths and have been reflected from obstacles and that are, further, with different phases. The sum of several signals with different phases follows the Rayleigh distribution in cases of randomly distributed phases.

[0003] Signal fading is, furthermore, dependent on the frequency of the signal. Thus, if a frequency difference between two signals is great enough, their fadings do not correlate. A difference of 1 MHz, for example, is large enough for signal fadings to be independent of each other.

[0004] The frequency selective fading of a signal described above is one reason for the introduction of frequency hopping technology in digital cellular radio networks. Frequency hopping means that the transmission frequency used in a connection is changed at predetermined intervals. Due to frequency hopping, the transmission quality can be improved especially in situations in which the terminal equipment moves very slowly or not at all as is often the case with, for example, hand-held phones.

[0005] Apart from the frequency diversity achieved by frequency hopping, the method is also advantageous in distributing the interference caused by the radio connection onto several frequencies, in which case momentary interference on any one frequency will remain small.

[0006] WO-A-9322849 discloses a digital time and frequency division multiple access cellular network wherein the traffic channels use frequency hopping. During time slots used for the control channel, all available frequencies other than the control channel frequency belonging to the hopping sequence. In other time slots all available frequencies belong to the sequence.

[0007] In the prior art solutions, if frequency hopping has been desired in a cell served by a base station, the base station equipment must have been provided with at least two complete transceiver units which contain base band sections and radio frequency sections. Each unit as such can form an independent base sta-

tion, but to implement frequency hopping several of them have been required in the same cell. This has resulted in that the base station equipment capable of frequency hopping has been disproportionately large in small cells in comparison with the capacity needed, and the implementation of frequency hopping has thus required heavy investments.

[0008] It is thus an object of the present invention to implement frequency hopping in a base station equipment economically and without creating excessive capacity.

[0009] This is achieved with the method of the type set forth in the introduction, which is characterized in that the second signal is divided in the time domain into several time slots, each of which transmits the same information as the first signal, except the time slot which transmits the common control channel of the base band equipment, and which carrier frequency is changed time-slot-specifically so that the frequency is either the same as the carrier frequency or different than that.

[0010] The invention also relates to base station equipment in a digital cellular radio system, said equipment comprising means for generating a base band data signal, a first means for transmitting a signal modulated by a certain carrier frequency, and said signal being divided in the time domain into several time slots of which one transmits the common control channel of the base station equipment and the other time slots information regarding different connections, an antenna, a second means for transmitting a signal modulated by a carrier frequency, elements for changing the carrier frequency used in the second means time-slot-specifically, and means for distributing the basic band signal to the first and the second transmitting means so that the signal transmitted by the second means is divided in the time domain into several time slots; characterized in that said second means transmits in each time slot the same information as the signal transmitted by the first means except the time slot that transmits the common control channel of the base station equipment.

[0011] The method of the invention can be applied for implementing frequency hopping in a cell comprising one transceiver unit. The base station in accordance with the invention can be built similarly to a conventional non-hopping base station, the only necessary changes being in the RF section of the transmitter. Only one base band section is needed. If frequency hopping is unnecessary, the base station of the invention can easily implement space diversity in a direction from the base station to the mobile station. The use of frequencies can be optimized so that frequency hopping is utilized only on weak connections.

[0012] In the following the invention will be described in greater detail with reference to the examples in accordance with the accompanying drawings, in which

Figure 1 illustrates time-slot-specific frequency

hopping,

Figure 2 shows an example of the structure of a base station equipment in accordance with the invention,

Figure 3 shows another example of the structure of a base station equipment in accordance with the invention, and

Figures 4a-4b describe the time slot construction of the output signal of the transmitting means.

[0013] The invention can thus be applied in the base station equipment of digital cellular radio systems such as the GSM system, for instance. In the following, the invention will be described when applied in a time slot structure of the type used in the GSM system, but without being restricted to that.

[0014] Figure 1 illustrates the implementation of time-slot-specific frequency hopping. The horizontal axis of the figure represents time, and the vertical axis represents frequency. The figure shows the frequency changes of one channel according to time slots. The base station changes carrier frequency at the beginning of every time slot, but the frequency is not changed during the time slot. The frequency is changed according to a predetermined sequence, in which case the receiver can monitor the hopping and receive the information contained in each time slot on a correct frequency. In a base station, each connection can have a hop sequence of its own, in which case the frequencies used in the time slots do not overlap.

[0015] Figure 2 is a block diagram of the structure of a base station equipment in which the method of the invention is applied. The equipment contains means 15 for generating a base band signal. The output 16 of said means 15 is connected to two transmitter units 10, 18 with the aid of a base band signal divider. The first transmitter unit 10 contains a carrier generator 12 whose output 26 is connected to a modulating means 13 whose second input is a base band data signal from the base band signal divider 17. The time division carrier signal 23 modulated by a base band signal is fed via an output amplifier 14 to an antenna 11. The first signal of the transmitter unit contains the common control channel BCCH of a cell served by a base station. By listening to that signal, mobile stations obtain information of the base station so that they can contact it, if necessary. In a GSM system, traffic on the BCCH channel is transmitted in the first time slot of a frame, indicated by the number 0. The other time slots, of which there are seven in a GSM system, transmit a signal that is either data belonging to a connection or, if the time slot is not in use, is a dummy burst. Figure 4a illustrates the structure of a GSM frame in which the first time slot 0 contains the BCCH channel, the second time slot 1 a dummy burst, time slots 2, 3, 4 and 6 data information, and time slots 5 and 7 a dummy burst. The carrier frequency of the transmitter 10 is marked with f_1 , and it is constant.

[0016] The second transmitter unit 18 correspond-

ingly contains a carrier generator 20 whose output 27 is connected to modulation means 21 whose second input is the base band data signal from the base band signal divider 17, i.e. the same signal as in the input of the first transmitter unit. In the example of the figure, the time division carrier signal 24 modulated by the base band signal is supplied via output amplifier 14 to an antenna 19. The signal of the second transmitter unit does not contain the common control channel BCCH, and the said time slot is not transmitted. In the other time slots 1-7 data belonging to some connection is transmitted, or the transmitter is switched off, if the time slot is not in use.

[0017] The carrier frequency used by the second transmitter unit hops time-slot-specifically under the control of means 25 so that with each connection (i.e. time slot) the frequency changes according to a predetermined sequence. In a base station in accordance with figure 2, in which two antennas are in use, the carrier frequency of the second transmitter unit can momentarily be the same as the frequency f_1 used by the first transmitter unit.

[0018] According to a second embodiment, when both of the transmitter units are on the same frequency, the second transmitter unit is switched off to avoid simultaneous transmission.

[0019] The second transmitter unit can be controlled time-slot-specifically so that frequency hopping is only performed in certain time slots. If two antennas are in use in connections not applying frequency hopping, both transmitters transmit the same signal on the same frequency, and space diversity is obtained.

[0020] Frequency use can be optimized so that frequency hopping is only applied to poor quality connections. To judge communication quality, signal strength as well as bit error and signal-to-noise ratios can be used as standards.

[0021] Figure 3 is a block diagram representation of an alternative structure of a base station equipment realizing the method of the invention. The equipment contains means 30 for combining signals from two transmitter units 10, 18 for transmitting via one antenna 11. The operation of a base station such as the one in figure 3 is similar to the above except that when one antenna is used, the second transmitter unit is switched off in cases where its carrier frequency is the same as the frequency of the first transmitter unit.

[0022] In addition to the components described above, the exemplary base stations also contain components other than those described, such as filters and divider amplifiers, but due to reasons of clarity they have been omitted from the figure as they are not essential to the present invention.

[0023] As explained above, figure 4a illustrates a frame structure transmitted by the first transmitter unit, the first time slot 0 containing the BCCH channel, time slots 2, 3, 4 and 6 containing data information (C1-C4), and time slots 1, 5 and 7 containing a dummy burst (B1-

B3). The carrier frequency of the first transmitter is indicated by f1, and it is constant.

[0024] Figure 4b illustrates a frame structure transmitted by the second transmitter unit. In the example illustrated in the figure, the transmitter unit utilizes three different frequencies, f2, f3 and f4 in frequency hopping. The number of frequencies can, of course, be something else in practice. Let us assume that connections C1, C2 and C4 using time slots 2, 3 and 6 employ frequency hopping, but connection C3 using time slot 4 does not hop. In such a case the second transmitter unit transmits a signal in time slots 2, 3 and 6 as shown by the figure, using at each moment of time one of the said carrier frequencies f2-f4. The second transmitter unit can, depending on the application, also use the frequency f1 of the first transmitter unit. The frequency used at each connection and each moment of time depends on the chosen hopping sequence which is specific for each connection.

[0025] The second transmitter unit can, for example, transmit a frame in accordance with figure 4b so that time slot 2 uses frequency f2, time slot 3 frequency f3 and time slot 6 frequency f4. In the next frame the time slots are changed so that time slot 2 uses frequency f3, time slot 3 frequency f4 and time slot 6 frequency f3. The frequencies of the time slots are independent of each other, and they can also be the same.

[0026] When two separate antennas are used, the second transmitter unit is able to transmit on non-hopping connections the time slot in question on the same frequency as the first transmitter unit in which case space diversity is achieved at the transmitting end. In the example above, the second transmitter unit can thus transmit the signal of connection C4 in time slot 4 on a frequency f1.

[0027] Even when using two separate antennas the second transmitter unit can be switched off if the frequencies of the transmitter units are the same; this can be done to avoid simultaneous transmission.

[0028] Even though the invention has been described in the above with reference to the examples in accordance with the accompanying drawings, it is obvious that the invention is not restricted by them but can be modified in a variety of ways within the scope of the invention as defined by the attached claims.

Claims

1. A base station equipment in a digital cellular radio system, said equipment comprising means (15) for generating a base band data signal (20), a first means (10) for transmitting a signal (23) modulated by a certain carrier frequency, and said signal being divided in the time domain into several time slots of which one transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different con-

nections, an antenna (11), a second means (18) for transmitting a signal (24) modulated by a carrier frequency, elements (25) for changing the carrier frequency used in the second means (18) time-slot-specifically, and means (17) for distributing the base band signal (20) to the first and the second transmitting means (10, 18) so that the signal transmitted by the second means (18) is divided in the time domain into several time slots; characterized in that said second means (18) transmits in each time slot the same information as the signal transmitted by the first means (10) except the time slot that transmits the common control channel (BCCH), of the base station equipment.

2. An equipment as claimed in claim 1 characterized in that the first and the second means (10, 18) comprise means (12, 20) for generating a carrier wave, means (13, 21) for modulating the carrier wave by a base band signal, and means (14, 22) for amplifying the modulated signal.
3. An equipment as claimed in claim 1, characterized in that the equipment comprises a second antenna (19) which is connected to the amplifier means (22).
4. An equipment as claimed in claim 1 characterized in that the equipment comprises means (30) for combining signals from two transmitters (10, 18) to be transmitted via one antenna (11).
5. An equipment as claimed in claim 1 characterized in that elements (25) change the carrier frequency employed by the second means (18) according to a predetermined sequence.
6. An equipment as claimed in claims 4 and 5, characterized in that the elements (25) switch off the second means (18) when the frequency indicated by the sequence is the same as the frequency used by the first means (10).
7. A method for implementing frequency hopping in a base station of a digital cellular radio system, in which base station a first signal (23) modulated by a base band data signal (16) is transmitted on a certain carrier frequency (26), which signal is divided in the time domain into several time slots of which one time slot transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different connections; and wherein the base station further transmits a second signal (24) modulated by the same base band data signal (16) on a certain carrier frequency (27), wherein the second signal (24) is divided in the time domain into several time slots; characterized in that each time slot of said second signal transmits the same information as the first

signal (23), except the time slot which transmits the common control channel of the base band equipment, and which carrier frequency (27) is changed time-slot-specifically so that the frequency is either the same as the carrier frequency (26) or different than that.

8. A method as claimed in claim 7, characterized in that the carrier frequency (27) is changed time-slot-specifically following a predetermined sequence.
9. A method as claimed in claim 7, characterized in that both the first and the second signal are transmitted via their own respective antennas.
10. A method as claimed in claim 7, characterized in that both the first and the second signal are transmitted via the same antenna.
11. A method as claimed in claims 7 and 10, characterized in that if the carrier frequency (27) indicated by the sequence and used by the second signal is the same in each time slot as the carrier frequency used by the first signal (26), the second signal is not transmitted.
12. A method as claimed in claim 7, characterized in that the second signal (24) is transmitted time-slot-specifically when the quality of the signal transmitted in the time slot is at the receiving end poorer than a predetermined threshold value.

Patentansprüche

1. Basisstationsausrüstung bei einem digitalen zellularen Funksystem, die Ausrüstung ist versehen mit einer Einrichtung (15) zum Erzeugen eines Basisbanddatensignals (20), einer ersten Einrichtung (10) zum Übertragen eines mit einer bestimmten Trägerfrequenz modulierten Signals (23), wobei das Signal im Zeitbereich in mehrere Zeitschlitze unterteilt ist, von denen eine den gemeinsamen Steuerkanal (BCCH) der Basisstationsausrüstung und der andere Zeitschlitzinformationen hinsichtlich verschiedener Verbindungen überträgt, einer Antenne (11), einer zweiten Einrichtung (18) zum Übertragen eines mit einer Trägerfrequenz modulierten Signals (24), Elementen (25) zur Zeitschlitz-spezifischen Veränderung der bei der zweiten Einrichtung (18) verwendeten Trägerfrequenz, und Einrichtungen (17) zur Verteilung des Basisbandsignals (20) an die erste und zweite Übertragungseinrichtung (10, 18), 80 daß das durch

die zweite Einrichtung (18) übertragene Signal im Zeitbereich in mehrere Zeitschlitze unterteilt ist;

dadurch gekennzeichnet, daß

die zweite Einrichtung (18) in jedem Zeitschlitz dieselben Informationen wie das durch die erste Einrichtung (10) übertragene Signal überträgt, jedoch mit Ausnahme des Zeitschlitzes, der den gemeinsamen Steuerkanal (BCCH) der Basisstationsausrüstung überträgt.

2. Ausrüstung nach Anspruch 1, **dadurch gekennzeichnet, daß** die erste und zweite Einrichtung (10, 18) eine Einrichtung (12, 20) zum Erzeugen einer Trägerwelle, eine Einrichtung (13, 21) zum Modulieren der Trägerwelle durch ein Basisbandsignal und eine Einrichtung (14, 22) zum Verstärken des modulierten Signals aufweist.
3. Ausrüstung nach Anspruch 1, **dadurch gekennzeichnet, daß** die Ausrüstung eine zweite Antenne (19) aufweist, die an die Verstärkungseinrichtung (22) angeschlossen ist.
4. Ausrüstung nach Anspruch 1, **dadurch gekennzeichnet, daß** die Ausrüstung eine Einrichtung (30) zum Verbinden von über eine Antenne (11) von zwei Übertragungseinrichtungen (10, 18) zu übertragenden Signalen aufweist.
5. Ausrüstung nach Anspruch 1, **dadurch gekennzeichnet, daß** die Elemente (25) die durch die zweite Einrichtung (18) verwendete Trägerfrequenz gemäß einer vorbestimmten Sequenz verändern.
6. Ausrüstung nach einem der Ansprüche 4 oder 5, **dadurch gekennzeichnet, daß** die Elemente (25) die zweite Einrichtung (18) ausschalten, wenn die durch die Frequenz angezeigte Sequenz dieselbe wie die durch die erste Einrichtung (10) verwendete Frequenz ist.
7. Verfahren zum Umsetzen von Frequenzsprüngen bei einer Basisstation eines digitalen zellularen Funksystems,

dabei wird bei der Basisstation ein durch ein Basisbanddatensignal (16) modulierte erstes Signal (23) auf einer bestimmten Trägerfrequenz (26) übertragen, dieses Signal wird im Zeitbereich in mehrere Zeitschlitze unterteilt, wobei ein Zeitschlitz den gemeinsamen Steuerkanal (BCCH) der Basis-

stationsausrüstung und die anderen Zeitschlitz Informationen hinsichtlich verschiedener Verbindungen übertragen; und

wobei die Basisstation zudem ein durch dasselbe Basisbanddatensignal (16) moduliertes zweites Signal (24) auf einer bestimmten Trägerfrequenz (27) überträgt, dabei ist das zweite Signal (24) im Zeitbereich in mehrere Zeitschlitz unterteilt;

dadurch gekennzeichnet, daß

jeder Zeitschlitz des zweiten Signals dieselben Informationen wie das erste Signal (23) überträgt, mit Ausnahme des Zeitschlitzes, der den gemeinsamen Steuerkanal der Basisbandausrüstung überträgt, und

wobei die Trägerfrequenz (27) Zeitschlitz-spezifisch verändert wird, so daß die Frequenz entweder dieselbe wie die Trägerfrequenz (26) oder von ihr verschieden ist.

8. Verfahren nach Anspruch 7,
dadurch gekennzeichnet, daß
die Trägerfrequenz (27) einer vorbestimmten Sequenz folgend Zeitschlitz-spezifisch verändert wird.
9. Verfahren nach Anspruch 7,
dadurch gekennzeichnet, daß
sowohl das erste als auch das zweite Signal über ihre eigenen jeweiligen Antennen übertragen werden.
10. Verfahren nach Anspruch 7,
dadurch gekennzeichnet, daß
sowohl das erste als auch das zweite Signal über dieselbe Antenne übertragen werden.
11. Verfahren nach einem der Ansprüche 7 oder 10,
dadurch gekennzeichnet, daß
falls die durch die Sequenz angezeigte und durch das zweite Signal verwendete Trägerfrequenz (27) in jedem Zeitschlitz dieselbe wie die durch das erste Signal (26) verwendete Trägerfrequenz ist, das zweite Signal nicht übertragen wird.
12. Verfahren nach Anspruch 7,
dadurch gekennzeichnet, daß
das zweite Signal (24) Zeitschlitz-spezifisch übertragen wird, wenn die Qualität des in dem Zeitschlitz übertragenen Signals auf der Empfangsseite schlechter als ein vorbestimmter Schwellenwert ist.

Revendications

1. Equipement de station de base dans un système de radiotéléphonie cellulaire numérique, ledit équipement comportant un moyen (15) pour générer un

signal (20) de données en bande de base, un premier moyen (10) pour transmettre un signal (23) modulé par une certaine fréquence porteuse, et ledit signal étant réparti dans la dimension temporelle en plusieurs tranches de temps dont l'une transmet la voie de commande commune (BCCH) de l'équipement de station de base et les autres tranches de temps transmettent des informations concernant des connexions différentes, une antenne (11), un deuxième moyen (18) pour transmettre un signal (24) modulé par une fréquence porteuse, des éléments (25) pour modifier la fréquence porteuse utilisée dans le deuxième moyen (18) d'une manière spécifique à chaque tranche de temps, et un moyen (17) pour répartir le signal (20) en bande de base entre le premier et le deuxième moyens de transmission (10, 18) de façon que le signal transmis par le deuxième moyen (18) soit réparti dans la dimension temporelle entre plusieurs tranches de temps ;

caractérisé en ce que ledit deuxième moyen (18) transmet dans chaque tranche de temps les mêmes informations que le signal transmis par le premier moyen (10), à l'exception de la tranche de temps qui transmet la voie de commande commune (BCCH), de l'équipement de station de base.

2. Equipement selon la revendication 1, caractérisé en ce que le premier et le deuxième moyens (10, 18) comprennent des moyens (12, 20) pour générer une onde porteuse, des moyens (13, 21) pour moduler l'onde porteuse par un signal en bande de base, et des moyens (14, 22) pour amplifier le signal modulé.
3. Equipement selon la revendication 1, caractérisé en ce que l'équipement comprend une deuxième antenne (19) connectée au moyen d'amplification (22).
4. Equipement selon la revendication 1, caractérisé en ce que l'équipement comprend un moyen (30) pour combiner des signaux provenant de deux émetteurs (10, 18) et destinés à être transmis par l'intermédiaire d'une seule antenne (11).
5. Equipement selon la revendication 1, caractérisé en ce que des éléments (25) modifient selon une séquence prédéterminée la fréquence porteuse employée par le deuxième moyen (18).
6. Equipement selon les revendications 4 et 5, caractérisé en ce que les éléments (25) arrêtent le deuxième moyen (18) lorsque la fréquence indiquée par la séquence est la même que la fréquence utilisée par le premier moyen (10).
7. Procédé pour mettre en oeuvre des sauts de fré-

- quence dans une station de base d'un système de radiotéléphonie cellulaire numérique, station de base dans laquelle un premier signal (23) modulé par un signal (16) de données en bande de base est transmis sur une certaine fréquence porteuse (26), lequel signal est divisé dans la dimension temporelle en plusieurs tranches de temps dont une première tranche de temps transmet la voie de commande commune (BCCH) de l'équipement de station de base et les autres tranches de temps transmettent des informations concernant des connexions différentes ; et dans lequel la station de base transmet en outre sur une certaine fréquence porteuse (27) un deuxième signal (24) modulé par le même signal (16) de données en bande de base, dans lequel le deuxième signal (24) est divisé dans la dimension temporelle en plusieurs tranches de temps ; caractérisé en ce que chaque tranche de temps dudit deuxième signal transmet les mêmes informations que le premier signal (23), à l'exception de la tranche de temps qui transmet la voie de commande commune de l'équipement en bande de base, et laquelle fréquence porteuse (27) est modifiée d'une manière spécifique pour chaque tranche de temps de façon que la fréquence soit identique à la fréquence porteuse (26) ou différente de celle-ci.
8. Procédé selon la revendication 7, caractérisé en ce que la fréquence porteuse (27) est modifiée d'une manière spécifique de chaque tranche de temps, en suivant une séquence prédéterminée.
9. Procédé selon la revendication 7, caractérisé en ce que le premier signal et le deuxième signal sont tous deux transmis par l'intermédiaire de leur propre antenne respective.
10. Procédé selon la revendication 7, caractérisé en ce que le premier signal et le deuxième signal sont tous deux transmis par l'intermédiaire de la même antenne.
11. Procédé selon les revendications 7 et 10, caractérisé en ce que, si la fréquence porteuse (27) indiquée par la séquence et utilisée par le deuxième signal est la même dans chaque tranche de temps que la fréquence porteuse utilisée par le premier signal (26), le deuxième signal n'est pas transmis.
12. Procédé selon la revendication 7, caractérisé en ce que le deuxième signal (24) est transmis d'une manière spécifique de chaque tranche de temps lorsque la qualité du signal transmis au cours de la tranche de temps est inférieure, à l'extrémité réceptrice, à une valeur de seuil prédéterminée.

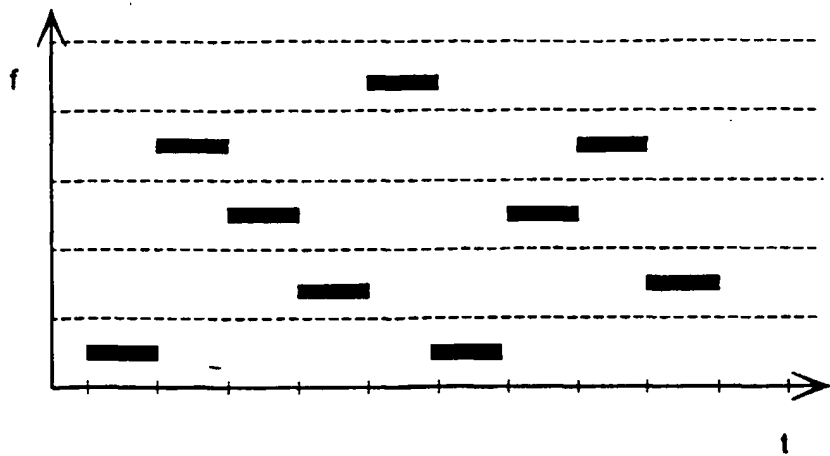


FIG. 1

	0	1	2	3	4	5	6	7
f1	BCCH	B1	C1	C2	C3	B2	C4	B3

FIG. 4a

	0	1	2	3	4	5	6	7
f2	-	-	C1	C2	-	-	C4	-
f3	-	-	C1	C2	-	-	C4	-
f4	-	-	C1	C2	-	-	C4	-

FIG. 4b

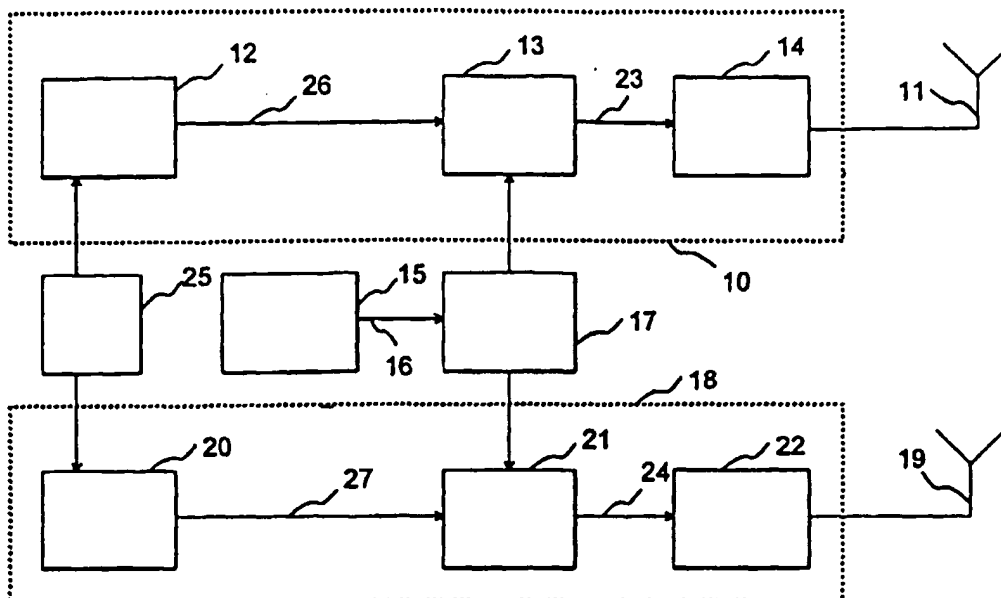


FIG. 2

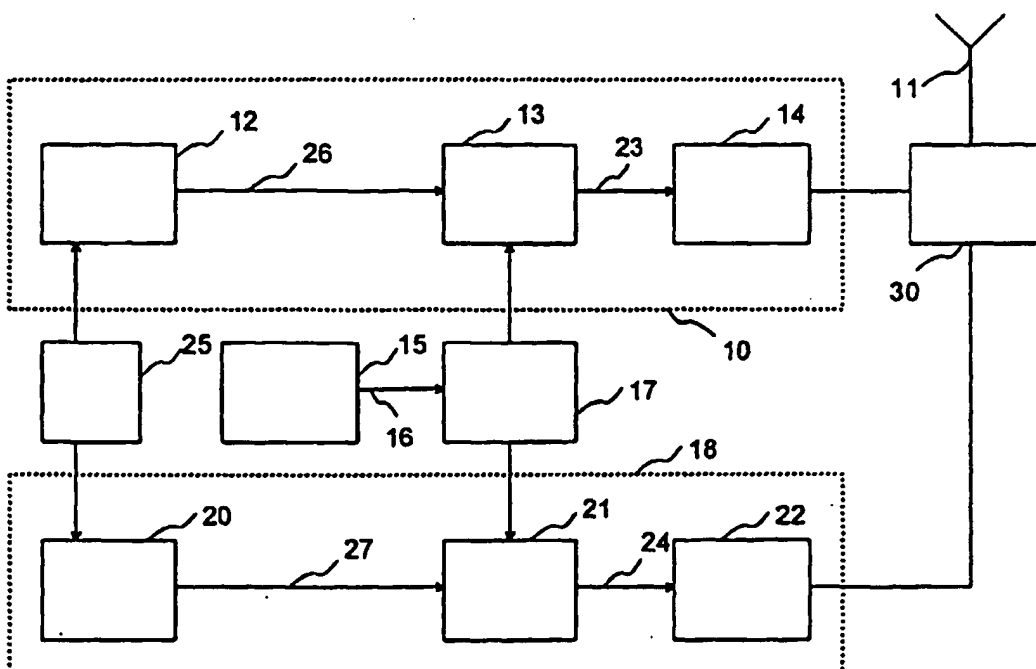


FIG. 3